

FUJI PREFABRICATED TYPE CLEAN ROOM SYSTEM

Madoka Uchida

1 INTRODUCTION

Clean rooms (hereinafter abbreviated to as CR) are so popular that they are essential as a basic technique of manufacturing method in the various modern industries, and CR using experiences are increasing. Consequently, such an idea as that only required functions of a CR should be remained and the rest should be omitted as much as possible has arisen. This idea is, in other words, "The main unit of a CR is an air treating equipment, and for the building and interior, it may be satisfactory as long as they have functions to segregate the CR from other zones".

Responding to this demand, We have developed a prefabricated type clean room system under the cooperation with Nippon Light Metal Co., Ltd. The system has already been used in various fields and the outstanding features have been recognized. This paper introduces the system.

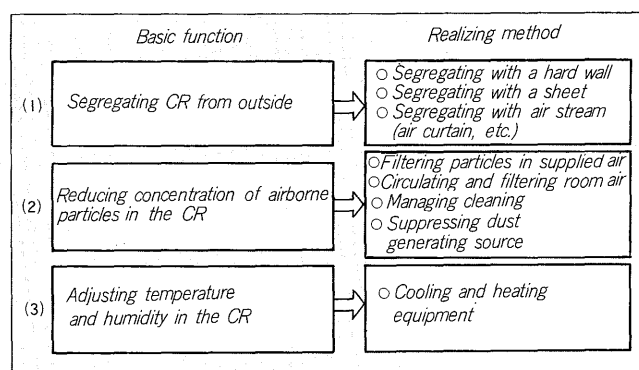
2 DEVELOPING PURPOSE AND FEATURES OF FUJI PREFABRICATED CR

Fig. 1 indicates three fundamental functions that CR must have and method to realize the functions.

Fuji prefabricated type CR system prefabricates the fundamental functions (1) and (2) in the Fig. 1 which characterizes the CR and provides the CR with a sufficient performance. The features are;

- (1) Can be built within a short period of time.
 - (2) Performance can be presumed correctly.
 - (3) Architectural finishing is stable.
 - (4) When expanding, the expanded portion can be finished equally to the already existing portion.
 - (5) Low cost.
 - (6) Can be built at any place.
- Further, as an accessorial function, the materials composing the wall and ceiling;
- (7) Are outstanding in heat insulating because temperature and humidity in the CR can be adjusted and maintained effectively.
 - (8) Have smooth surface and high corrosion resistance.

Fig. 1 Basic functions of CR



(9) Derive air-tight construction easily.

For the fundamental function (1) having these elements, assembly type withstanding wall construction is advantageous, and the surface of the wall and ceiling panels must have been finished completely before assembling them.

As a panel which has all of these performances, Fuji Electric developed an aluminum sandwich panel. The model of this panel is same for refrigerator panel developed by Nippon Light Metal Co., Ltd. which already had a proven service life.

As for the fundamental function (2), method to reduce number of particles floating in the CR, the air inside the room must be circulated and the air must be filtered by an air filter. As an equipment having this function, the HEPA filter box with built-in fan (Fuji Clean Unit) was selected.

Under the standard specifications, the cleanliness of Fuji prefabricated CR system is Class 10,000 or higher. This cleanliness class denotes that the concentration is about 1/100 of a manufacturing plant where an ordinary air conditioning is made, therefore air cleaning effect will be sufficient.

Fuji prefabricated CR is so flexible that it can be applied sufficiently to highly precise industrial product assemblies without changing the standard specifications, and it can be used as a high performance CR equivalent to practical class 100 also by using a clean bench and clean

Table 1 General specifications of Fuji prefabricated CR

Basic function	Rated cleanliness	JIS Class 5 (Fed Std. Class 10,000)	<ul style="list-style-type: none"> • Cleanliness can be changed by controlling number of clean units.
	Required power	1.6 kW/10 m ²	<ul style="list-style-type: none"> • Clean unit WLK14E08 0.4 kW, Illumination 80 W × 4 = 0.32 kW • Air shower AS-31 0.8 kW
	Construction period	10 days/100 m ² after starting the construction	
	Wall and ceiling	Prefabricated panel of wall type structure 900 wide × 2400 height (mm) 900 wide × 1800 long (mm)	<ul style="list-style-type: none"> • Foamed urethane filled aluminum sandwich panel • The surface aluminum is bake-painted in double • Joint seal: RTV Silicon
	Furnishings	Aluminum flush door 1 door/100 m ² 1800 wide × 2000 high (mm) Fixed sash window 1 window/10 panels	<ul style="list-style-type: none"> • Fitted in frame, semi-air-tight type. • Air-tight type is option • With transparent glass, The sash is made of aluminum
	Floor	Long vinyl chloride sheets joined by means of a welding	<ul style="list-style-type: none"> • Dimpled surface • Rounded skirting is an option
	Illumination	Average brightness 400 lx	<ul style="list-style-type: none"> • Up-side down triangle fluorescent lamp, 40 W × 2 tubes
	Receptable and switch	One place per 10 panels	<ul style="list-style-type: none"> • Wall buried type • Wiring conduit 20 VP
	Air shower	AS-31 A 1 unit	<ul style="list-style-type: none"> • Jet blow 20 m/s • Commonly used for entrance and exit
	Path box	PS-40-40 1 unit	
	Static pressure regulating damper	1 unit	
Option function	Temperature/humidity regulation	According to temperature and humidity of the installed room	
	Temperature/humidity regulation	Package air conditioner or air handling unit	<ul style="list-style-type: none"> • Room temperature control accuracy ±2 °C
	Installation of devices to be attached to wall	Installation plate is buried in the panel	
	Wiring for power required in manufacturing	3 ϕ 200 V per conduit pipe, 11.4 kVA or less	
	Wash basin	Unit type is desirable.	
	Outside air treating unit		<ul style="list-style-type: none"> • With built in fan and medium efficiency filter • Used at the place where dust density of taken outside air is high.
	Air circulating duct		<ul style="list-style-type: none"> • A grill is installed on the side wall. • An external duct is installed to control air flow in the room.

booth to enhance the operation management.

3 GENERAL SPECIFICATIONS AND COMPONENT PARTS OF FUJI PREFABRICATED CR

Based on the combinations of the standardized wall and ceiling panels and clean unit, Fuji prefabricated CR is equipped with an air shower, path box, illumination and power outlet required as minimum attachments as a system. Further, under the optional specifications, an external duct air circulating system, temperature/humidity adjusting system, outside air taking-in equipment, hand washing basin, etc. are also available, and by combining these attachments, a higher class CR system can be composed.

Table 1 and Fig. 2 indicate the general specifications and concept of Fuji prefabricated CR.

3.1 Wall and ceiling panels

The panels which compose the wall and ceiling (See Table 2 and Fig. 3.) use aluminum sheets in both the interior and exterior, and foamed urethane heat insulating material is filled in between the aluminum sheets. This aluminum wall has a sufficient withstanding force, and for those of up to 3.6 meter gable, the wall can be built completely independently. When the gable exceeds 3.6 meters, auxiliary column and reinforcing suspended from the bulding must be used. (Fig. 3.)

The panel surface is bake-painted, and after assembling at the site, the wall and ceiling can be used immediately as the joints are calked. The surface paint of the panel is resistive against the chemicals shown in Table 3, and by using silicone calking agent and vinyl chloride system calking agent for the joint calking between panels, the room withstands against almost all working environments.

Further, for those place where the panel of this

Fig. 2 Concept of Fuji prefabricated CR

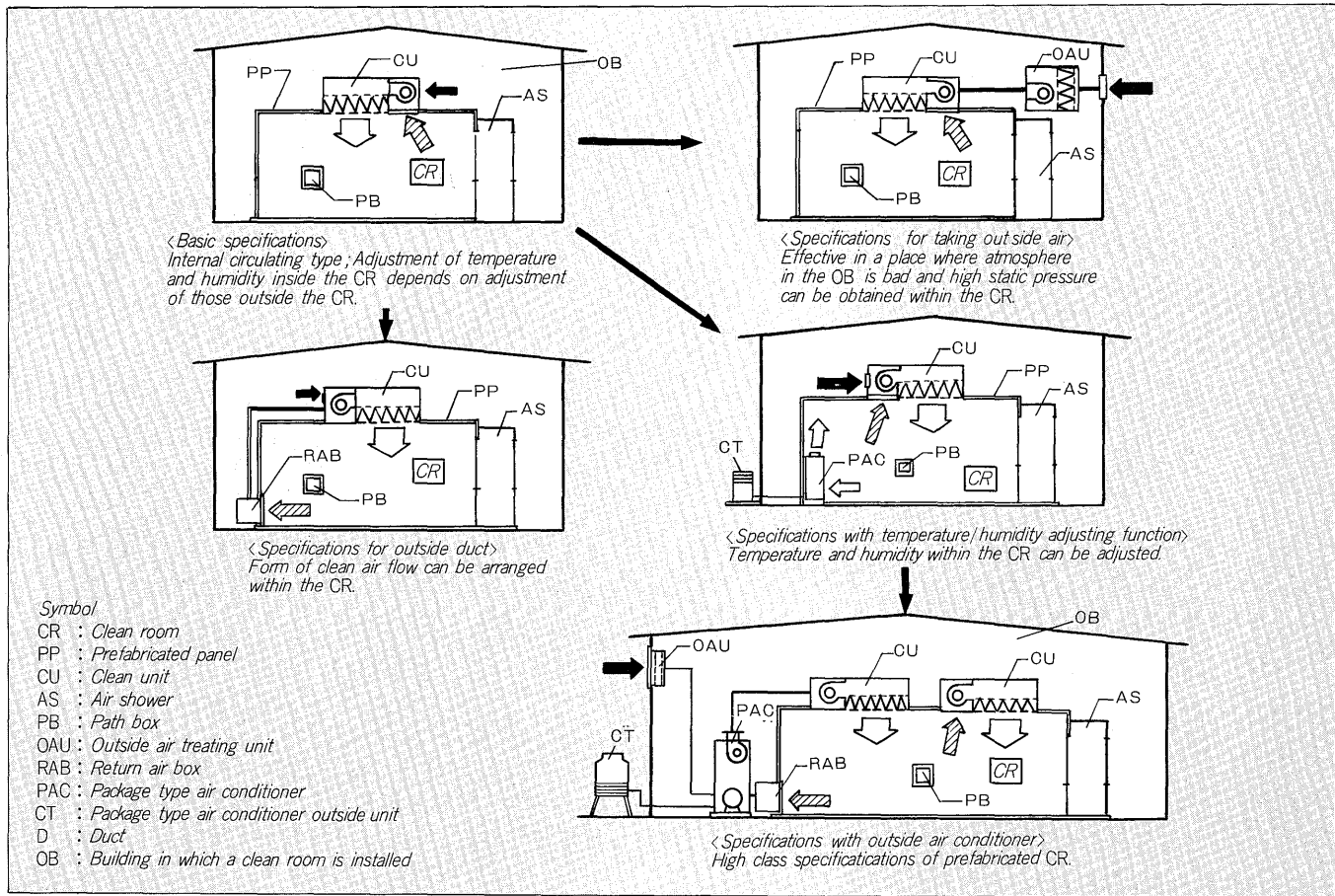


Table 2 Specifications for wall and ceiling panels

Name	Width	Height. Length	Material	Color	Remarks
Wall panel	900 mm	2,400 mm	Surface material: Color aluminum sandwich panel	Ivory	Pain specifications: 2 coats, 2 bake
Ceiling panel	900 mm	1,800 mm	Panel thickness: 42 mm		
Heat insulating material	—	—	Hard polyurethane foam SE class (self-extinguishing foam)	—	Specific gravity: 0.03~0.04 Heat transfer rate: 0.018 kcal/m·h·°C

standard specification cannot be used due to the limitations by the architectural standard law and fire regulations, fire resisting panel and semi-non-inflammable panel are available under a separate series.

3.2 Floor and skirting

Under the standard specifications, long vinyl chloride sheet welded floor and skirting are used. (Fig. 4) For those applications which require floor cleaning, a painted floor is available under an optional specification. Under the standard specifications, normal skirting is used, and rounded skirting is under an optional specifications.

Smoothness is the primary importance of the floor of CR, but practically, slipping during walking is taken into consideration, and floor having dimpled surface is used.

3.3 Clean unit

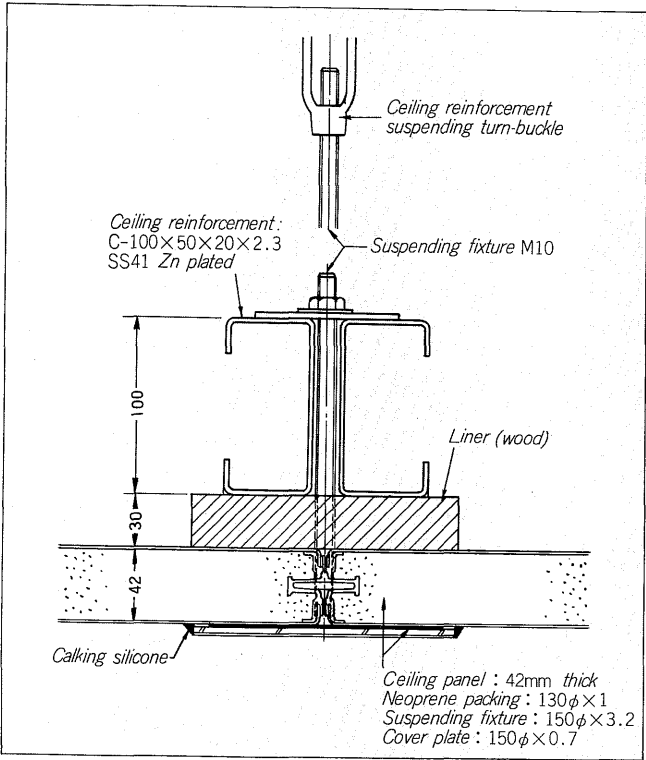
The clean unit (Fig. 5, Table 4) sucks the air inside the

CR with the built-in blower, and supplies clean air of Fed. Std. 209b class 100 (JIS Class 3) into the CR after filtering with the high efficiency filter. Under the standard specifications, one clean unit is installed per 10 m² CR floor space, and in this case, the clean air is circulated about 30 times per hour. The built-in HEPA filter is of a 99.97% or higher (0.3 μm or more DOP) dust collecting rate. Needless to say, the concentration of number of particles of supplied air is decided depending on the number of particles contained in the sucked air. Hence, when intending to maintain class 100 cleanliness of the supplied air, particle concentration at the sucking port must be maintained in class 100,000 (JIS Class 6).

Especially, in many cases, the places where prefabricated type CRs are installed are ordinary working places, and therefore, cleanliness of the air taken into the clean unit must be thoroughly examined.

When there is a high dust generating work in the CR,

Fig. 3 Details of ceiling reinforcement



special considerations such as to install a local exhaust device are required.

3.4 Air shower

Under the standard air shower specifications, Fuji Electric type AS31A is installed. When many number of people pass through, one for many people is installed as an optional specification. Moreover, the air shower is normally used commonly for entrance and exit.

3.5 Path box

Under the standard specifications, Fuji Electric type PS40-40 path box is used.

3.6 Illuminations

It is standard to use up side down triangle type fluorescent lamp using two 40 W tubes. When the CR is of a class 10,000, the standard illumination has a sufficient function. However, when the work is of a high dust rate or when sterilization is required at food and pharmaceutical industries, hermetic flush lamp is used as an option.

3.7 Fittings

(1) Entrance/exit door

Air shower is used commonly for worker entrance and exit. For small parts and devices, path box is used.

To carry in and out large devices, a 1800 mm wide and 2,000 mm high (nominal dimensions) aluminum flush door is used. When it is necessary to enhance airtightness, an air

Table 3 Chemical resisting test results of prefabricated panels

Name	Left side prefabricated panel (color aluminum)	Center vinyl chloride steel plate	Right side color steel plate
Formalin (35%)			
Phenol (10%)			
Caustic soda (10%)			
Hydrogen peroxide (10%)			
Acetic acid (10%)			
Hydrochloric acid (10%)			
Nitric acid (10%)			

tight door is used as an option. (Fig. 6)

(2) Window

A fixed sash window (Fig. 6) is installed per 10 standard panels as standard.

Fig. 4 Floor and skirting

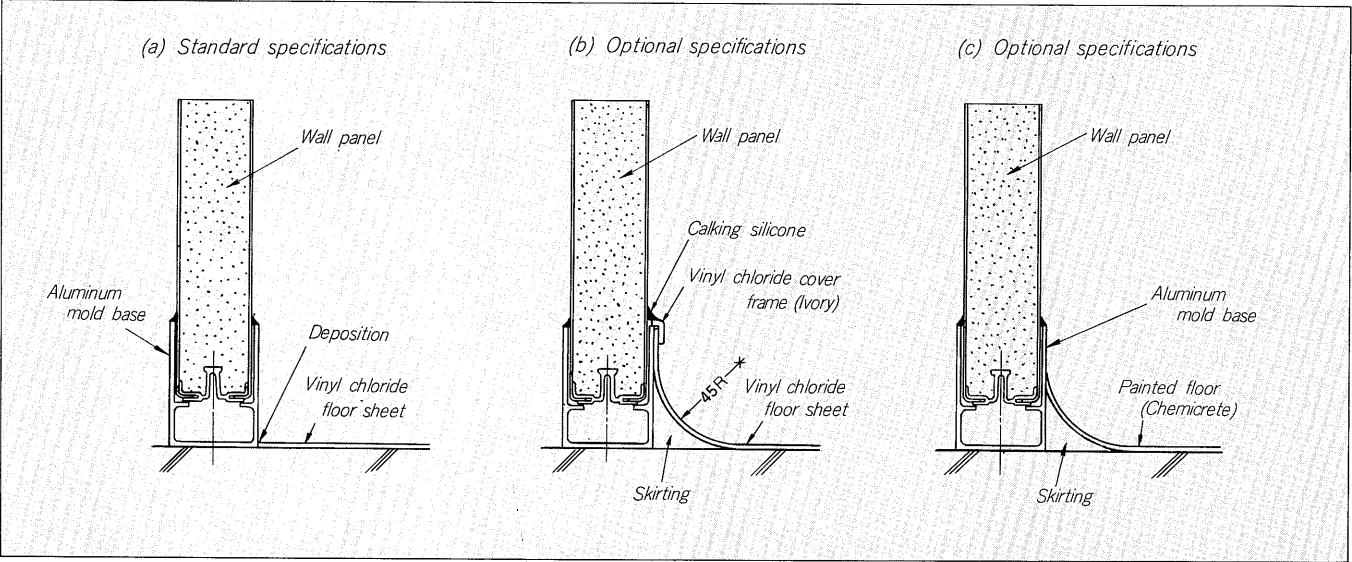


Fig. 5 Clean unit

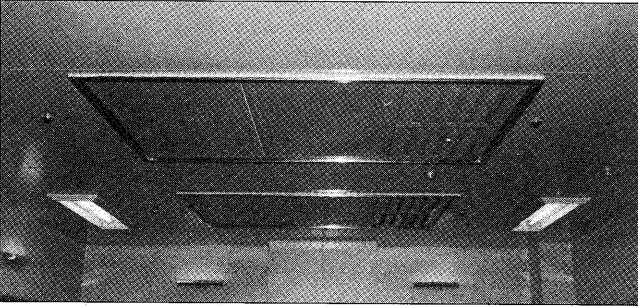


Fig. 6 Semi-air-tight door and window

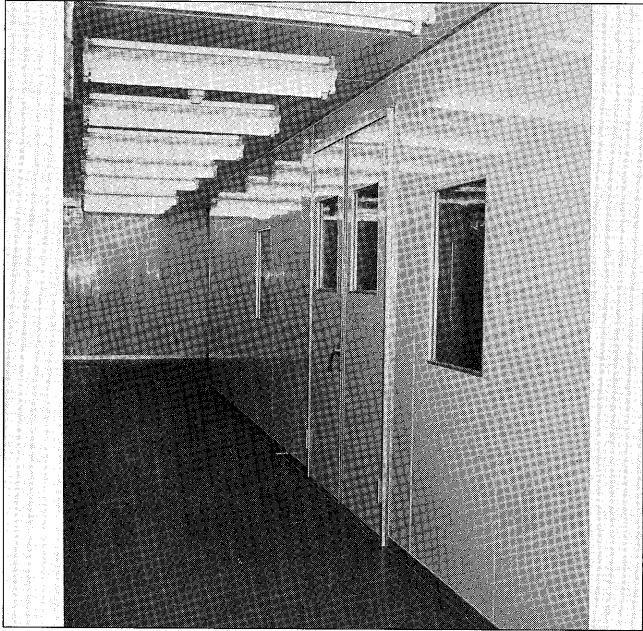


Table 4 Clean unit specifications

Model	WLK14E08
Class	100 (0.5 μm or more)
Rated air volume	18 m ³ /min
Used HEPA filter	Dimensions Height 610 x Width 610 x Depth 150 (mm)
	Quantity 2
Noise	65 phon
Input power	AC 3 ϕ 200 V 50/60 Hz
Power consumption	430 W
Weight	150 kg

(3) Dressing room

It is desirable to install a dressing room or dressing corner as a preliminary room of the air shower. The dressing room should be a semi-CR. As an option, a dressing room of the same specification as the CR is available.

3.8 Power outlet, switch and power distributing panel

Buried wiring can be made within a panel of the standard specification up to 20VP conduit pipe, and under the standard specification, it is made at one position per 10

sheets of panel. For this reason, power wiring of 11.4 kVA/ 3 ϕ 200 V or greater cannot be buried but the conduit pipe is exposed outside the panel (option). The CR side terminal of the wiring conduit pipe is sealed by means of a calking so that air is not leaked.

Further, when it is necessary to install a power distributing panel on the panel, a base plate must be buried under the panel in advance at the location where the power distribution panel is installed. (Fig. 8)

3.9 Heating and cooling equipment

A proper heating and cooling equipment is selected after calculating energy load in the CR. The equipment

Fig. 7 Power outlet box buried in panel

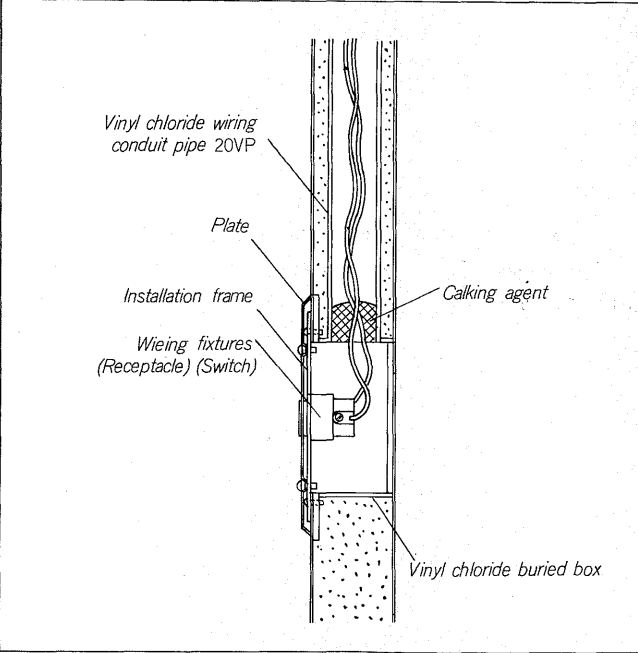


Fig. 8 Panel for attachment installations

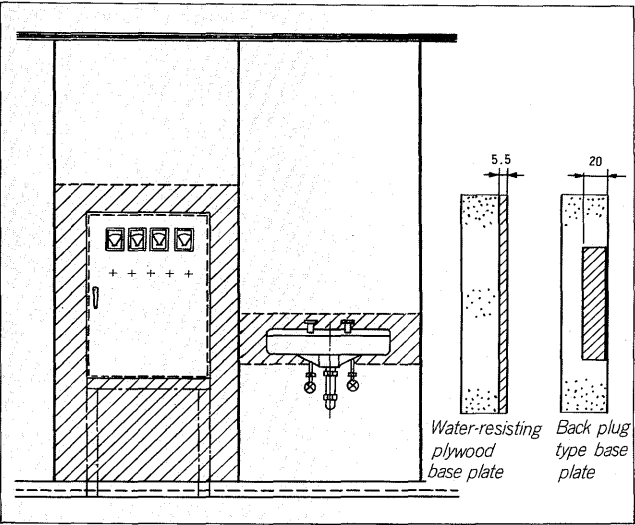


Table 5 Interior limitations of buildings

Land, Construction and Scale Segment		Total floor area of the portion used for the appropriate purpose			Interior limitation		Architectural standard law
		In case of fire-resisting building	In case of semi-fire-resisting building	In case of other buildings	Living room, etc.	Mainaasile, staire, and passage going to the ground	
(1)	By number of floors and scale	<ul style="list-style-type: none">• Number of floors is 3 or more and exceeding 500 m²• Number of floors is 2 and exceeding 1000 m²• Number of floor is 1 and exceeding 3000 m² (Excluding school and gymnasium)			Non-inflammable material Semi-non-flammable material Hard burning material		129 · (4)
(2)	Room where fire is used	Residential house: House having 2 or more floors, and room where fire is used in a floor other than the top floor Other than residential house: All rooms where fire is used			Non-inflammable material Semi-non-inflammable material	—	129 · (6) 128-4 · (4)
(3)	Those having 11 or more floors	Portion where fire-prevention is segregated within 100 m ²			(1) is applied	Non-inflammable material, Semi-non-inflammable material	112 · (5)
		Portions where fire-prevention is segregated within 200 m ² (Excluding Class OTSU fire preventing door)			Non-inflammable material, Semi-non-inflammable material (with base material)		112 · (6)
		Portion where fire-prevention is segregated within 500 m ² (Excluding Class OTSU fire preventing door)			Non-inflammable material (with base material)		112 · (7)

installed in the CR should be as smallest and simplest as possible. When cold or hot water is supplied, a fan coil unit is selected, or when not supplied, air cooling heat pump type air conditioner is selected. When the CR requires a temperature/humidity control of higher accuracy, an air regulator is installed outside the CR. These arrangements are shown in Fig. 2.

4 EXAMINATIONS FOR BUILDING FUJI PREFABRICATED CR

When building a prefabricated CR, the place and purpose must be examined thoroughly in advance. Especially, the compliance with the relative regulations is important.

4.1 Limitations due to architectural standard law

The panel of Fuji prefabricated CR of the standard specification has not been licensed as fire resisting, non-inflammable, semi-non-inflammable or hard-to-burn material, and depending on the installed place and application, use of Fuji prefabricated CR may be limited. *Table 5* digests the matters regarding interior limitations of the Architectural Standard Law Executing Ordinance. When the primary purpose of prefabricated CR is considered, however, in a broad mean, the CR may be considered to be an air cleaning device. Therefore, it is important to consult with the relative governmental office as required. Moreover, the fire resisting and semi-non-inflammable panels are available under a separate series, and they can be used as applicable to the purpose.

When floor space of one room of prefabricated CR exceeds 100 m², exhaust equipment for smoke of fire is required. When the exhaust equipment is a smoke exhausting equipment, an emergency power supply must be prepared. Details for this matter are omitted because they exceed the main purpose of building a prefabricated CR.

4.2 Selecting a place where CR is built

The floor of the already existing building on which a prefabricated CR is installed must be smooth and horizontal. The floor should be repaired before installing the prefabricated CR when necessary. The total height of Fuji

prefabricated CR is height of the ceiling (inside of CR) plus 500 mm. Therefore, the place selected must have a height of the total height of the prefabricated CR plus 400 mm. (Refer to *Fig. 9*.)

To install a prefabricated panel, it must be distanced minimum of 100 mm from the existing wall and column as working space is required.

4.3 Work inside the CR and resisting performance of panel

The panel of the standard specification has a sufficient corrosion resisting performance against almost all working environments except for special working environment (plating plant, etc.). (Refer to *Table 3* above.)

5 EXAMPLE OF INSTALLATION

(1) Pharmaceutical plant (*Fig. 10*)

To maintain a low room temperature, the heat insulating characteristics of the panel are used effectively. Further, the panel surface is hardly to be moistened, improving the mold preventing effect even in a high humid atmosphere.

(2) Precise parts assembly room (*Fig. 11*)

It is effective to use a prefabricated CR when making a part of the manufacturing process to be a CR. Since thickness of the panel is thin, the effective area can be expanded. A temperature/humidity control system is also provided.

(3) Multi-purpose study room (*Fig. 12*)

Fig. 9 Dimensional view of Fuji prefabricated CR

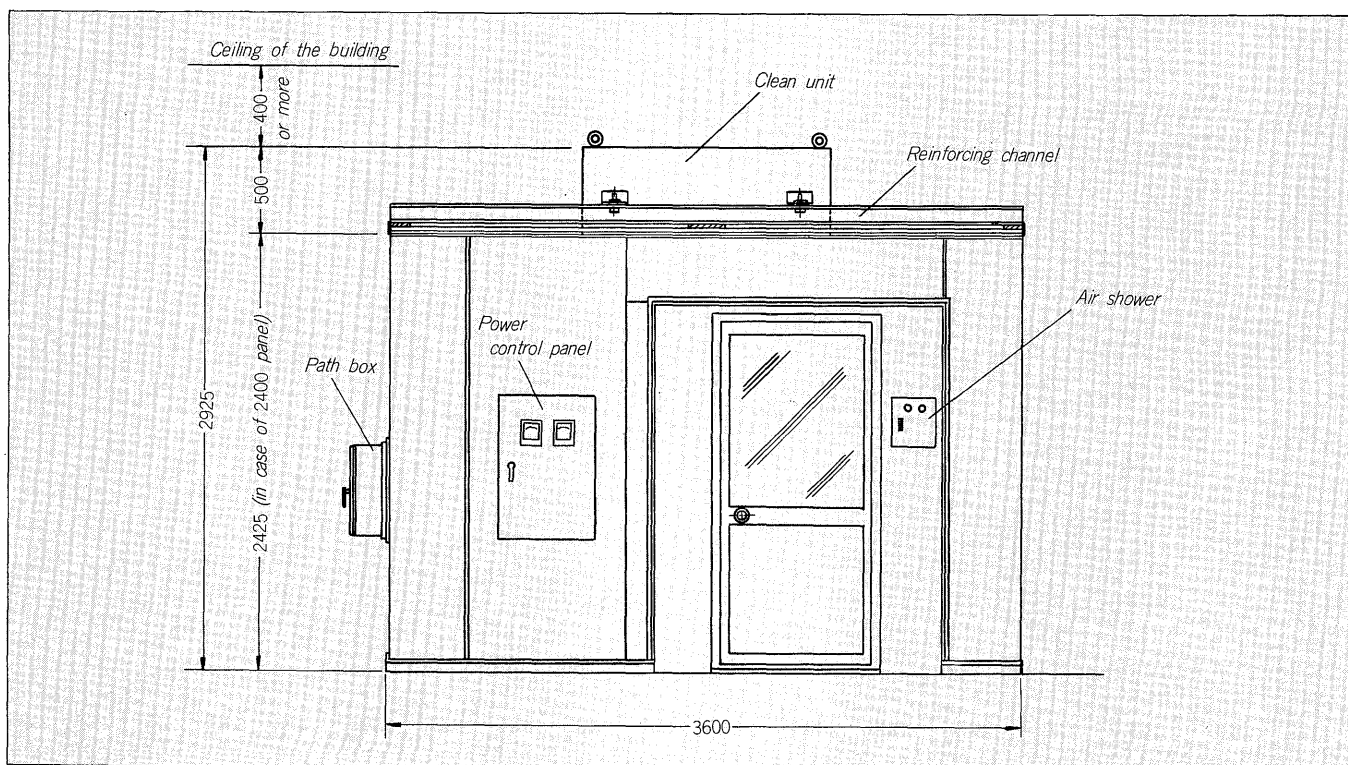
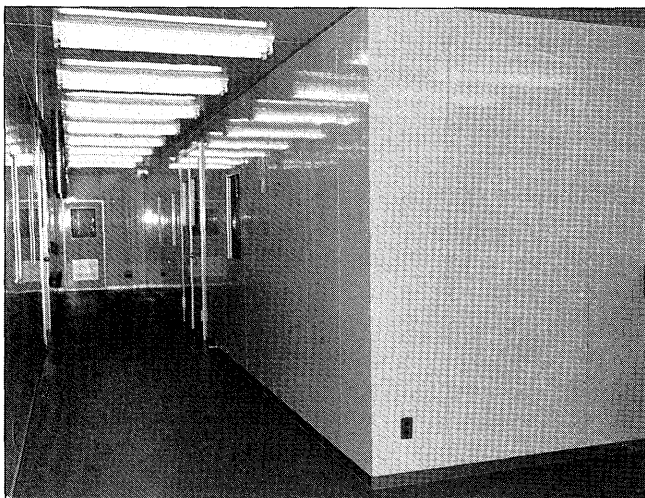


Fig. 10 Pharmaceutical plant

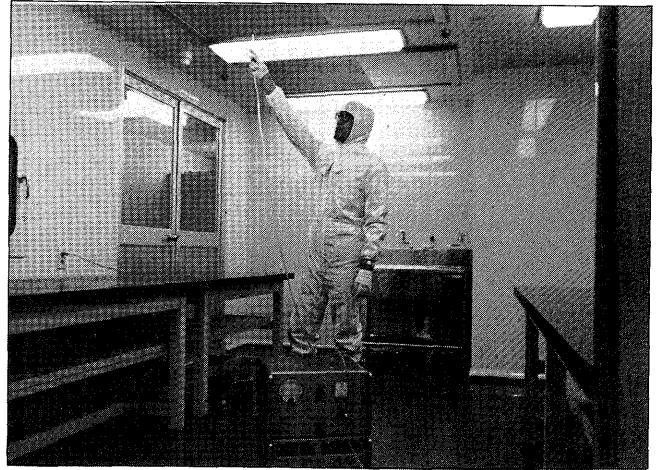


Fig. 11 Precise parts assembling plant



The cleanliness can be changed by controlling number of clean units.

Fig. 12 Multi-purpose study room



6 POST SCRIPT

Recently, it is likely to select a portion of the manufacturing process where cleanliness is required and to maintain a required cleanliness in that portion only. This idea has been born from such self-examinations as that CR may be likely to be an excessive equipment. It can be said that the prefabricated CR is suited to this application. Further, movement and expansion can be made without damaging the already using panels. Contrarily, however, the used wall and ceiling panels are damaged easily by an impact on their surfaces, and this is only one disadvantage. Although precautions are required partially for the use, as the application of CR to all fields is expanded, CRs of comparatively small scale will be built more and more. In a occasion like this, the effectiveness of the Fuji prefabricated CR will be proved.

Closing this paper, we should like to express our deep appreciations to those of Nihon Keikinzoku Co., Ltd. who gave us greatest cooperations in developing the panels and building the CR system.